HF Direction Finding

by Chris Plummer BSc., C.Eng, FIChemE, MSaRS, G8APB

IT MAY SEEM STRANGE that a Class B licensee is writing about HF. However you do not even have to be licensed to take a full part in this technical sport. HF or more precisely Top-Band (160m) direction finding (DFing) is now approaching its 70th anniversary in the UK, and is still regarded by many as either too tough (a *man's* sport) or a 'black art'.

In reality it is only a combination of skill and accuracy in taking bearings with a radio set, map reading and a heck of a lot of luck. In fact I have described it as the ultimate game of adult hide and seek. At club level it is just the thing to raise a thirst or an excuse to go to the pub after the event. This pastime (for time does pass extremely quickly especially when you cannot find the transmitter) is for young and old alike; my son started when he was seven and there are still pensioners at it, even at national level.

The equipment is still regarded by many as very highly specialised, but the main requirements are only a directional antenna (ie a ferrite rod or frame) and a screened case for the works of the set. In the past some competitors have modified ordinary medium wave receivers to cover 160m by retuning the front end. However, most 'serious' competitors now have purpose-built sets suitably 'ruggedised' to take the inevitable knocks, and of course the competitor also takes the knocks, so be warned.

In the early years of DF, all the receivers were battery valve sets. These progressed to discrete component transistor sets, but with the advance in technology most of the best receivers in use today use the basic integrated circuit design that will be described later in this article. The overall cost of what is a rather useful 160m receiver is no more than £20-30 with judicious purchasing at local rallies.

A SPORT FOR ALL AGES

I WOULD DEFINE THE sport of DFing as 'finding a deliberately well hidden transmitter (and its crew) by taking cross bearings with a suitable radio receiver and physical searching in the immediate locale of the transmitter site'.

As I intimated above, it is a 'sport' for all ages and all professions, as indeed is amateur radio in general. Anyone can take part, and all are very welcome to do so. It is advisable, however, firstly to team up with an existing competitor, to gain experience in the wiles of the sadistic TX crews and get a feel for the behaviour of LF signals and receiver performance. It is no good leaving the car five miles from the Tx because the signal was so strong.

Many of the competitors will present a lecture to a club and organise a local club event as a demonstration, or for the less fit, put on an indoor computer based competition which can be just as cut throat as the real thing. First contact should be through the National RSGB Direction Finding committee who will then organise a local lecturer.

The author takes a bearing with the DF set described in this article.

There are eight RSGB qualifying rounds held throughout the summer, organised by local clubs throughout the country, and a National Final for all the qualifiers, held in September each year.

In a qualifying round, the competitors have two transmitters to locate and are provided with a form to be signed and timed by the transmitter operator(s). The winner being the first to find his second transmitter. On the National Final this is the first to find three transmitters. All competitors assemble at a pre-arranged start point on a particular Sunday (see the RSGB contest calendar) to sign in and prepare to take bearings on the first fixed-time signals from the transmitters at 1320-1324BST. If signals are successfully heard, the teams are then allowed to disperse after plotting their bearings.

The transmitters must be located on the same 1:50,000 Ordnance Survey (OS) map as the start point, with a practical route to each without the need to trespass. At 1400-1404BST there is a second fixed-time transmission from all transmitters. The aim of all team members is to place themselves in such a position as to obtain a good cross bearing to reduce the possible area of search.

Bearings may be taken at as many points as necessary to finally locate each transmitter. However, after 1404BST the Tx schedule is random, but there must not be a gap greater than 15 minutes between transmissions, or a period of transmission less than 2 minutes. Thus, it is up to the skill of the competitors to find the transmitters, and the guile of the Tx crews in timing and hiding to keep them out for a reasonable time to ensure a competitive result. No-one likes a competition that is over in an hour or takes all afternoon to find one station, especially if you have come from the other end of the country.

The bearings taken at the start are plotted on the OS map. Further bearings are then taken at other locations, the theory being that they should all cross at the transmitter. This in fact is rare, and even if it does happen you tend not to believe it. Inaccuracies can occur for one or all of these reasons:-

- Bent signals eg re-radiation from power lines,
- Inaccurate compass or reading the map wrong,
- Human error - a major cause,
- Reversed sense or no sense at all *[this is a technical DF term and does not refer to the operator - Ed]*.

Experience and luck (mostly the latter), as is usual, play important roles.

Having got as close as possible to the apparent transmitter location (my son is always briefed to say "Don't get out of the car too soon Dad"), the competitor and helpers then leave the vehicle and walk, run or crawl, dependent on the site, towards the Tx.

Close to the site, (under the aerial) the gain of the front-end of the set cannot be turned back any more and the set blocks and nulls or sense cannot be obtained. This is generally an indication that you are within a few yards (or tens of yards) of the hide which will in most cases be almost impenetrable thorn or other nasties that provide good camouflage. It is then up to you how determined you are to get

in the easy/slow way, or beat your own path as quickly as possible.

The general rule is that no more than four people are allowed per team, thus allocation of 'duties' are roughly:- set-operator/team-leader; driver; navigator and bush-beater/operator-carrier (especially when he's tired). Most teams comprise fewer members than this, even down to single operators. However, you need to have made a pact with some evil being to do well at all the jobs on your own.

RECEIVER SPECIFICATIONS

1. Cover the whole of 160m, 1.81-2.0MHz.

Transmitters may be anywhere on the band and are generally crystal controlled as Vfos drift and can be knocked off frequency.

2. Reasonable selectivity.

You must be able to sort out the real transmissions from the other occupiers of 160m ie 'fishphones', beacons etc, and receive AM transmissions, thus a 5-6kHz wide, reasonably sharp filter will suffice.

3. Easily tuned and accurately calibrated.

On many occasions I have heard complaints that the set won't tune to the Tx frequency. Also, any knocks to the dial must be easily noticed and rectified, as you could easily waste 15 minutes waiting tuned to the wrong frequency.

4. Portability.

A large frame aerial or ferrite rod mount may give more accurate bearings, but it is not the thing to go through the undergrowth dragging behind you. Also, weight is of the essence; the extra two pounds really saps the energy in the run in/out.

5. A sense system.

It is possible to locate the transmitter(s) without being able to select which null the Tx lies in, but it will take longer to do so. Thus an *untuned* whip aerial is phased in to the main aerial via a wideband amplifier. Of course reverse sense is still a problem but should be sorted out before the event.

6. A BFO.

It is much easier to hear a null of the carrier with an audio beat and is a must to identify the Tx from the CW transmissions (even take bearings on the CW). An advantage of leaving the BFO on is that it swamps the misleading audio that some Tx crew's give out etc. As a beginner, it is useful to be 'talked-in' occasionally, so switch it off sometimes.

7. Headphone output.

This is a must for weaker signals, and keeping your information on bearings and strength to yourself, but be prepared to listen for shouts in the undergrowth. S-meters and tuning indicators are not generally a good idea as they can cause confusion and are not robust. Meters also contain magnets (see below).

8. Provision for RF Attenuation.

Close in under the aerial, or even a mile or so away depending on TX power, the set will block so no null or sense can be obtained. Thus effective attenuation or RF gain control is essential. Even a short across the aerial, or a shorted turn, is crudely effective.

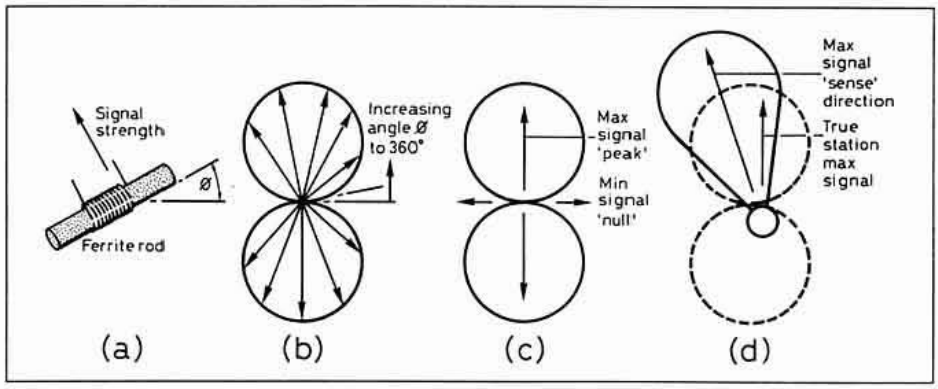


Fig 1: Showing the effect of rotating the aerial, and of adding a 'sense' whip

9. Audio/IF gain control.

Your ears can only stand so much beating.

10. Robustness.

The case and aerial must be capable of withstanding knocks, bangs, dropping from great heights and generally being dragged through unforgiving undergrowth. It is no good trying to repair a mangled set whilst sitting in the middle of a wood with no work bench.

11. Reasonably waterproof.

This goes hand in hand with the robustness of the set. It is a well-known British weather trait that it only rains when you are furthest from cover, even if you set out in sunshine. Rivers, canals and streams are also full of water!

12. As light as possible.

A small lightish set is a must, as running long distances with the weight of a 'ghetto blaster' soon saps the strength of even the superhuman, especially up hill and down dale. Consideration should also be given to the shape, and ease of forcing ways through the undergrowth.

13. Rapid access to the works.

Batteries can and do go flat at critical times (you should have checked the set before the start!). Thus the ease of opening a die-cast box is an advantage and it also seals well. Remember when considering power sources - where do you get charged NiCads on a Sunday afternoon or dead of night?

14. Reasonable stability.

It doesn't help if the receiver has drifted off frequency between transmissions.

15. Reasonable sensitivity.

The station may well be running lower power or be some distance away, but remember the RF attenuator for close work.

16. Screening.

Obviously, for good close in work you only want the signals to enter the set through the aerials, thus a tight fitting metal (aluminium) case is essential. An electrostatic screen around the aerial is not essential, but does help make it robust, and tends to aid the accuracy of bearings.

17. No magnetic materials.

As you will be using the set in combination with a compass, do not use ferrous materials or magnets eg meters, if at all possible, as they will affect the bearings. It is presently almost impossible to get batteries without steel casings (NiCads are worse), thus care must be observed in mounting the compass far enough away so as not to be unduly affected.

18. KISS.

Keep it simple, stupid. This is almost the most important pre-requisite, as running repairs do occasionally need to be carried out, in the car if not in the field. If you haven't got the frills they can't go wrong.

THE THEORY

SIMPLE TRIALS WITH an ordinary medium-wave portable receiver tuned to any station will show a marked broad maximum signal with the set broadside on to the transmitter, and deep nulls (or minima) off the ends of the set or aerial. On sets with a ferrite rod, the nulls will occur when the signal appears to come from a direction in-line with the rod, whereas with older sets with a frame aerial, the nulls will be apparent when the frame is broadside on to the transmitter. In fact, both nulls are in the line of the axis of the windings on the rod or frame. If the signal strength is plotted against angle theta as the set is turned, a Cos theta relationship is obtained as shown in **Figs 1 (a) and (b)**.

As can be seen from **Fig 1(c)**, there are two equal, relatively broad maximum signals, and two much narrower nulls. To obtain an accurate bearing on a station, one or other of the nulls is utilised. Thus you get two bearings opposite to each other. You could settle for this and move to another location to take another set of bearings and select the ones which cross, but to make things easier only one bearing is ideal.

This can be done by phasing the signal from an untuned 'sense' whip in with the main aerial signal, after amplification, to obtain roughly equal signal levels from the whip and frame or rod. This phase mixing distorts the double circle pattern such that a distinct difference can be judged from the two maxima of the main aerial Fig 2(d). It is then relatively easy to decide which is the correct direction. It is not advisable to take this new higher maximum signal from the 'front' of the set as a bearing as it is usually offset from the true maximum direction. It should be used only to decide which null to take as the bearing.

MAPS

ONCE A BEARING IS obtained, you then

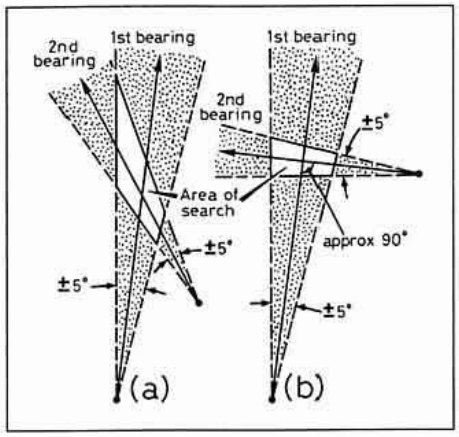
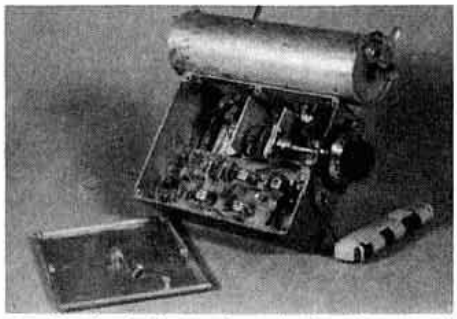


Fig 2: Making cross-bearings reduces the area of search very quickly.

have to transfer it to a map. The series usually used is the 1:50,000 Ordnance Survey. These are 40km square so the transmitters can be anywhere in 1,600 square kilometres - a needle in a haystack?. The compass will be calibrated 0 to 360° magnetic ie 0 or 360° is magnetic north, 90° is east magnetic, 180 is south magnetic etc. Care must be taken here to allow for the difference between these magnetic referenced bearings and grid north, ie the vertical lines on the map. There is quite a difference which varies over the years and where you are in the country.

Inspection of the edge of OS maps will give the variation of the various norths, grid and true north stay the same, but the magnetic pole slowly rotates about a fixed point thus giving about a half degree movement over an eight year period so an up to date map is essential. The latest revision will also hopefully show the new road networks, but this takes some time to get through the system, so some local knowledge is useful. However, magnetic north can generally be fixed at 6-8° west of grid north, thus an offset can be built in to the mount of the compass or the sighting device to make it easy to plot the compass bearings directly on the map against the grid lines.

Having obtained a bearing relative to grid north, then pinpoint your actual position on the map, align the centre of a full circular protractor at this position and set zero/360° to the top of the map, ie align the axis 0 - 180° with a vertical line on the map. Then plot the bearing with a sharp softish pencil, HB will do, and using a ruler carefully extend this to the edge of the map. It is possible, but rather messy, to use an overlay or plastic coated map, marked with a felt tip pen or china graph crayon. This has the advantage of keeping the map dry.



The direction finding receiver, showing the compact and rugged construction.

BEARINGS

YOU HAVE NOW PRODUCED the first or start bearing. Don't worry if you couldn't hear anything of the transmissions, approximate bearings are readily available for those that need them. The next thing to remember is that at best your bearing accuracy is +/-5°, and at worst due to various factors +/-30°. You should then choose a suitable location for second bearings so that, ideally, this second bearing crosses the first at as near 90° as possible. This will reduce the area of possible search required, and it is a good idea where possible to reduce your distance from the hidden station so that this area is reduced even further, see **Fig 2**.

As the number of transmissions and time goes on, further bearings can be taken, gradually closing in on the Tx, and eventually the car is abandoned. The run in should be judged to be as short as possible to give time for bush beating. On arriving closer to the transmitter site some RF attenuation is turned in to avoid overload of receiver and ears. At this time the advantages of good screening is evident as the null becomes gradually less evident.

After many possibly frustrating minutes, or even hours, you will probably find the sadistic so-and-so who has been operating the Tx. Hopefully you find it before anyone else, but that is where some of the luck comes in.

A SIMPLE RECEIVER DESIGN

BY REFERENCE TO THE circuit diagram, **Fig 3**, the general simplicity of the design can be seen. This set is a derivative of the author's published design which used a TAD100 IC at the heart of the set. Due to the general unavailability of the chip and the need to wind your own coils with 42SWG wire it was decided to re-design the set. Many of the features and sub-circuits are in fact the same, however the oscillator and mixer coils are now standard pre-wound coils.

BASIC BUILDING BLOCKS

TR1 AND ITS ASSOCIATED components form the untuned sense amplifier. Input gain is adjusted by the length of the telescopic whip, whereas the best sense on a distant station is set firstly by using a 10k linear preset in place of R1, then substituting a fixed resistor. This gives a more robust design. As the sense amplifier is not required all the time it is switched by S1. Output from the sense amp is passed by the low value capacitor Cx (nominally 2.2pF) to the input of the RF amplifier TR2.

The main signals enter the set via the frame or rod antenna which is peak tuned by C26, nominally 50pF. The joint main, or main and sense, signals are passed through the RF attenuator R17 (a 100k lin pot) to the gate of the RF amp TR2. Gain of this stage is set by preselection of R16. A value of 220R seems to work in the sixty or so sets used up to now.

Output of TR2 is passed to a tap on L1 which is tuned against ground by C21 with its padding and spreading capacitors, C23 and C24. These should be selected for best band-

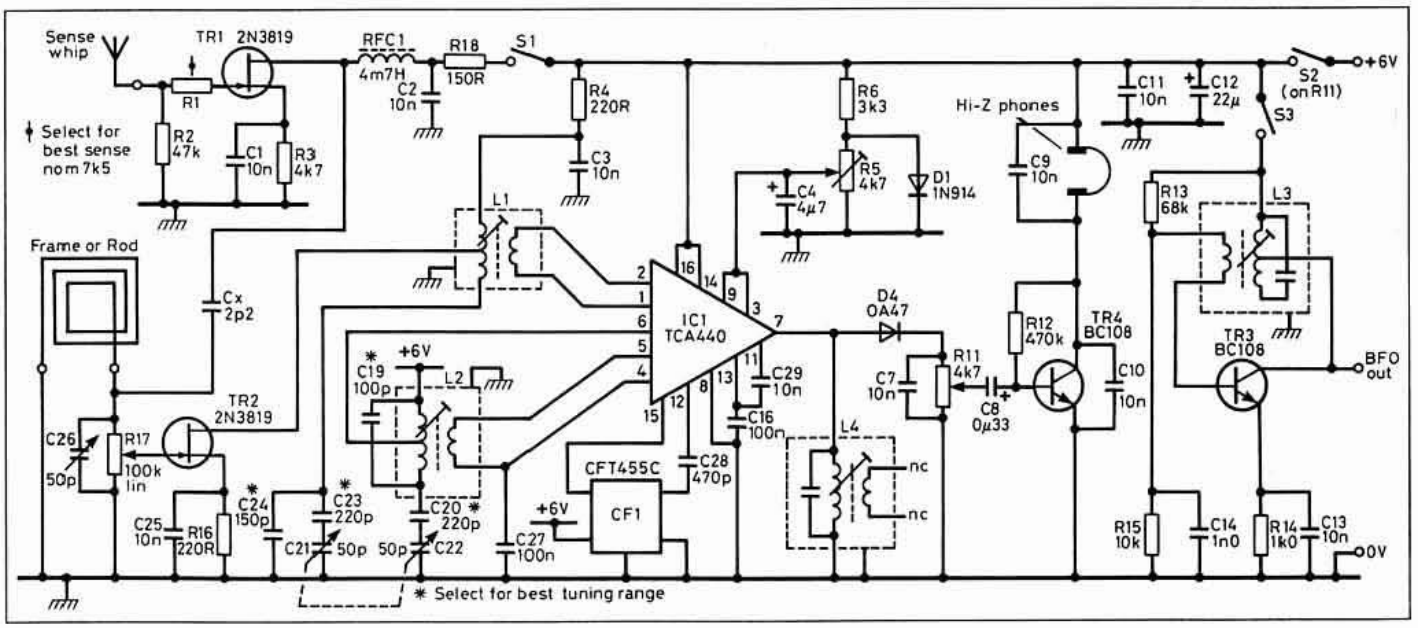


Fig 3: The simple but very effective purpose-built Top Band DF receiver.

COMPONENTS LIST

(DON'T WORRY IF some numbers are missing, it's due to developments. There should be 11 fixed resistors and 20 capacitors on board and 2 caps off board apart from the variables).

Resistors (all on board)

150R	R18	10k	R15
220R	R4, R16	47k	R2
1k	R14	68k	R13
3k3	R6	470k	R12
4k7	R3	7k5 SOT	R1

4k7 lin preset horiz R5

Capacitors (on board unless stated)

2.2pF ceramic Cx (not on board, could be twisted pair of wires)	
100pF ceramic	C19
150pF ceramic	C24
220pF ceramic	C20, C23
470pF ceramic	C28
1000pF ceramic	C14
10nF (0.01µF) poly	C1, C2, C3, C7, C9 (not on board), C10,C11, C13, C25, C29
100nF (0.1µF)poly	C16, C27
0.33µF tant	C8
4.7µF tant or elec	C4
22µF tant or elec	C12

Active components

IC1	TCA440
TR1, TR2	2N3819
TR3, TR4	BC108
D1	1N914 or 1N4148
D2	OA47

Wound components

CF1	Toko	CFT455C
L1, L2	Toko	154AN7A6440
L3, L4	Toko	YRCS12374
RFC1	Toko	4.7mH minimum RFC

Off board

4k7 log with switch	R11
100k linear	R17
50+50pF vari	C21+C22 or strip down a larger value
50pF or 100pF vari	C26
Small SPST switches to suit	S1, S3 (S2 is part of volume control)

Case approx 7in x 5in x 1.5in
2ft 6in whip to suit case

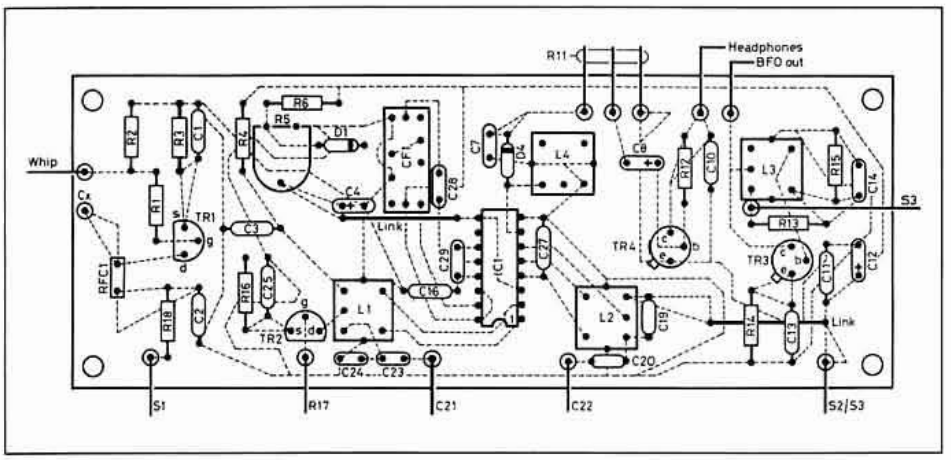


Fig 4: Component layout and connection details. (PCB artwork will be published next month).

spread and tracking with the oscillator. Values given work well.

Most of the rest of the receiver chain is contained within the IC TCA440. This includes the local oscillator, and RF/IF stages, apart from the frequency selection and tuning components. The oscillator is controlled by L2 and tuned by C22 with padding and spreading capacitors C19 and C20. The IF selectivity is given by a standard small Toko ceramic filter CF1 CFT455C, but any within the range would do. This filter has a bandwidth of 6kHz. DC isolation for the output of the filter is obtained with C28.

As it is imperative that the signal strength can be judged by how loud it appears, the AGC systems are disabled by a preset voltage on pins 3 and 9 of the IC by the preset R5 with a cheap zener across it - a reverse-biased silicon diode D1 1N4148/1N914. R5 is adjusted for best gain when setting up with fresh batteries. In fact, the later audio gain could be fixed and R5 used as the gain control, this has the advantage that the intermediate stages of the set are protected from overload. In practice, this makes little difference to the set's operation if good screening and layout is used around the RF attenuator.

The IF signal from pin 7 of the IC is peaked by the broad tuned L4, a standard IF transformer or suitable coil. Audio demodulation is obtained with the germanium diode D4 OA47. This is different from the TAD100 design as this contained the demodulator within the IC. With audio gain set by R11, which also contains the on/off switch S2, final amplification to high impedance phones (or a transformer to low Z) is with TR4 BC108. The final items on the circuit L3, TR3 and components surrounding them form the BFO. Output is taken as an insulated wire from the collector of TR3 pushed under the main IC. The position of this varies the coupling as required.

REFINEMENTS

THIS DESCRIBES THE standard diagram. However, one or two alternatives have been developed, notably an inductively coupled sense amp and varicap tuning for mixer and oscillator.

Inductive coupling of the output of the sense amp is obtained by substituting for RFC1 a one or two turn coil around the frame or rod, and leaving out Cx. Some competitors in fact switch the direction of this coil instead of turning the set, but this adds complication.

Varicap tuning is accommodated on the board layout and is achieved by substituting the circuit below for C21 and C22 with adjustment of the values of C19, 20, 23 and 24.

RECEIVER CONSTRUCTION

THE RECEIVER CAN BE built by any standard technique. However, it is essential to keep the front end RF stages and aerial input well screened or judiciously located. To this end, a printed circuit board has been designed such that no internal screens will be needed. This board, which is approximately 50mm x 150mm is designed to carry the majority of the components except S1, S3, R11/S2, C_x, C26, R17, C21/C22, C9. These are the major mechanical components and thus best mounted on the case.

When planning the set, it is best to start with an idea of the size and mounting of the antennas together with the case size. Remember that you will have to accommodate a battery pack as well as the PCB, and a slow motion drive for the tuning. General layout as per the photograph of the author's set is reasonable and well tried.

A frame antenna of approximately 10 or 12 turns on a frame to suit the case size also provides a convenient carrying handle. This can be made from wood or metal but remember not to form a shorted turn if metal is used. Also the wire should be in the centre of a metal channel to reduce capacitive effects. If a ferrite rod is used, approximately 20 or 25 turns at the centre of the rod mounted in a slotted metal tube or insulating mount also used as a handle.

The author uses a 1/2in x 8in rod supported at the ends in perspex discs, and the tube filled with urethane household foam after final alignment so that the rod is not broken in use.

The component plan for the PCB is shown in **Fig 4**. There is a generous allowance of space to accommodate almost any sized modern components (the author has even contemplated using a leadless component layout but keeps dropping the chip Rs and Cs). Start by mounting the coils and IC then the Rs, Cs and active components.

When the board is complete, run an insulated wire from TR3 just under the legs of IC1 and stick down with tape but not touching any track or pin, this gives plenty of BFO insertion. Double check the board for faults and connect to the box mounted items, it is best to use fairly stiff wire for the oscillator tuning capacitor C22 to avoid microphonics, as with any construction of a VFO.

Set R17 to max signal ie top of the track, connect a milliammeter between the battery and +ve set rail and switch on. The set should burst into life. Now set the tuning to the HF end of the band and set L2 core to tune 2.455MHz. Check that the oscillator tuning will go down to 2.265MHz with some overlap at both ends of the band ie above 2.0MHz to below 1.81MHz. Peak the tuning of L1 to around 1.9MHz and set R5 for best gain. Peak C26 for best gain and find a local top-band signal to listen to. The sense amplifier is set up by comparing the front to back response of the set with the sense whip fully up and the amp switched on. R1 is then adjusted for best front to back ratio. It is easier to substitute a small preset for R1 to get best response then measure the resulting resistance and put in the closest fixed value you have in the junk box. You could always leave the preset in, but reliability would suffer. ❑

FOR MORE INFORMATION about HFDF, write to RSGB DF Committee Chairman, Brian Bristow, G4CBB, Camelot, Princess Street, Piddington, High Wycombe, Bucks, AP14 3BN.

PENPALS

Benito Calvar, EA1CNL, would like to make contact with an English speaking amateur, both for correspondence and radio contact. Anyone interested write to Benito at PO Box 1.110, 36.200-VIGO, Spain.

We have received a photograph from Romila Daniel, YO2LCG, a 26-year old electronics engineer requesting amateurs to send him letters or postcards in English. If you would like to contact him, send your letters to Romila Daniel, Str Circum-valatiunii, Nr.69 SCA AP 28, Timisoara 1900, Romania.

VIDEO RECORDER

Could anyone advise Ben Follows, G4FJU, of a modern video recorder compatible with the 80/40M bands. Most seem to have a play-back frequency in the 3.8MHz region, and filters do not seem to help. The problem is direct pick up on the play-back head, and short of encasing the whole unit in lead there is no cure. Any advice to Ben at 1 Avon Road, River Est, Bloxwich, Walsall, WS3 1PA.

ROYAL FREE HOSPITAL REQUEST

Alan Charles, G4ORE, has asked whether there is a retired electronics or radio engineer (or enthusiast) who would consider spending a little of his time as a volunteer in the Electronics Department of the Royal Free Hospital, Hampstead. They are looking for someone who would enjoy taking obsolete equipment to pieces and recycling the component parts, as well as finding customers for usable equipment. A canteen lunch ticket and local travelling expenses would be provided - and a friendly welcome. Please contact Alan on 071 794 0500 (Ext 3198).

AIRCRAFT MUSEUM

Dr Manning, G4GLM is involved in a major project in his aircraft museum and is trying to find some grey or clear/colourless embossing tape of any make or width, so as to enable him to relabel parts of the two-crew twin-jet airliner cockpit for educational purposes. All responses gratefully acknowledged and costs reimbursed. Please telephone him on 081 958 5113 (home), or 081 952 7176 (work).

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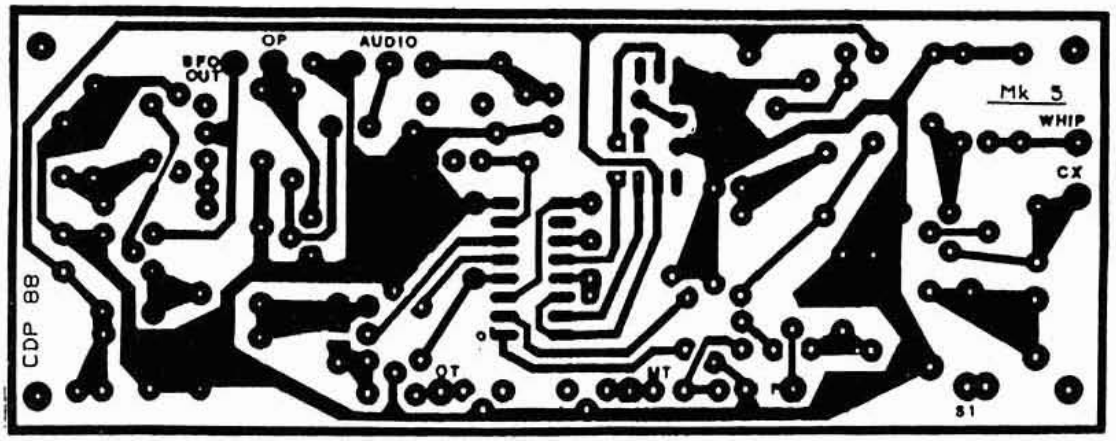
HF DIRECTION FINDING

(June)

PCB of artwork for last month's top band DF project.



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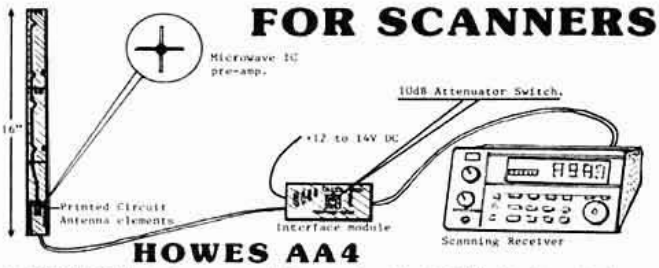

HOWES AA4

The **HOWES AA4** Active Antenna gives full coverage from 25 to 1300MHz. It is designed to be the ideal solution for those requiring a compact, broadband antenna for use with scanning receivers. The AA4 features advanced technology with a low noise microwave IC amplifier.

- ★ Fully broad-band covering 25 to 1300MHz
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AA4 Kit: £19.80 **Assembled PCB modules: £26.80**

AA2 ACTIVE ANTENNA for 150kHz to 30MHz

The **HOWES AA2** is the active antenna to use for general coverage HF reception. Broad-band performance that does not tail off at the higher frequencies. The neat, compact answer for those with limited space, holiday use, mobile operation etc. Two selectable gain settings, local or coax powering (12 to 14V). IP3 +38dBm. Easy to build and much liked by customers!

AA2 Kit: £8.50 **Assembled PCB: £12.90**

HF SSB and CW RECEIVERS

Our range of simple, but very effective receivers opens up the world of long distance radio communications for a very modest outlay. Most of the kits listed below are designated for use on various amateur bands. Give us a ring to discuss your requirements for frequencies not shown here.

The kits contain the electronics to build the receivers. "Hardware packages" contain the mechanical items (case, dial, knobs, sockets etc) to go with the "works" supplied in the basic kit. In addition, all our amateur band receivers have **matching transmitters** to suit the **Novice** and full amateur licence. These can be combined with other kits to form complete transceiver projects.

SSB/CW RECEIVERS		Kit	Assembled PCB
DXR10	3 Band (10,12 & 15M) for DX amateur work	**£26.60**	**£39.90**
DcRx54	4.45MHz Aircraft band (rescue etc)	**£15.90**	**£22.70**
DcRx20, 40 or 80M	Single band amateur receivers.	**£15.90**	**£22.70**

DXR10 Hardware package: **£14.90** **DcRx Hardare** package: **£16.50**

RECEIVER ACCESSORIES			
CBA2	Buffer to enable use of DFD5 counter	**£5.90**	**£9.50**
CSL4	Sharp, dual bandwidth (SSB & CW) filter	**£10.50**	**£17.40**
DCS2	"S Meter" kit for above receivers	**£9.20**	**£13.80**
DFD5	Digital frequency counter/display	**£41.50**	**£64.50**
XM1	Crystal Calibrator, 8 marker frequencies	**£16.90**	**£22.80**

CV100 - ADD SHORTWAVE TO YOUR SCANNER!

This kit converts 1 to 40MHz up to 101 to 140MHz so you can tune these frequencies with a normal VHF scanner. No mods to the radio are needed.

CV100 kit: £26.50 **Assembled PCBs: £37.90**

PLEASE ADD £1.20 P&P to your total order value.

HOWES KITS are produced by a professional RF design and manufacturing company. They contain a good quality printed circuit board with screen printed parts locations, full clear instructions and all board mounted components. Sales and technical advice are available by phone during office hours. Please send an SAE for our **free catalogue** or specific product data sheets.

73 from Dave G4KQH, Technical Manager.